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MACROCOSM, MICROCOSM, AND ANALOGY

John North

ANALOGY—AN INTRODUCTION

The analogy between microcosm and macrocosm has in its time been many things, varying from an inspiring axiom to a tired cliché, but it deserves to be considered as something more than a pretty figure of speech. Analogy is so rarely taken seriously, except as a literary or theological device. Take Mark Twain's story *Tom Sawyer Abroad*, for example. Tom Sawyer there tries to persuade his friends of the truth of the account of the flying bronze horse in the *Arabian Nights*. If a balloon can fly, moved and steered by buttons—the year is 1894—why, by analogy, shouldn't a horse also fly, steered by a peg in its shoulder? For the benefit of his obtuse friends Huckleberry and Jim, Tom waxes philosophical on the question of similarity of form and principle. It is Huck the empiricist who puts an end to the discussion, not with a principle but with a brute fact. Horses *can't* fly. It's as simple as that. Jim is the juryman in the case, and he is entirely convinced. All that Tom can manage to say is that listening to Huck and Jim trying to argue makes him ashamed of the human race.¹

Here is just one out of a potentially endless series of quotable instances of analogy coming under attack. Analogy might have its logic, but of what use can it possibly be if it leads to the conclusion that horses can fly? It might be of use to poets, or to writers of tales fit for the *Thousand and One Nights*, but surely not for the advancement of the sciences? (For the time being I will leave aside its uses in philosophy.)

I believe that the role of analogy in the sciences is indeed important, even though it may be forgotten after the theory that it helped to shape is finished. How it functions in the course of scientific discovery will not be my concern here, but it will be as well to bear in mind the very different attitudes people have had towards it down the ages. Some

¹ Twain, *Tom Sawyer Abroad*, end of ch. 12.

analogies have been considered to have continuing value, in the way the steel frame in a skyscraper is of continuing value, and others have been regarded as disposable commodities, like the scaffolding put round a building when it is being built. Consider for a moment those familiar historical analogies between the Sun in the heavens, the heart in the human body, and the king in his kingdom. Sixteenth- and seventeenth-century writers, having formulated them, went on to use them to *explain* something and to convince us of its truth—of its physiological truth or its political truth, for instance. The analogies were chosen because they were familiar. They strike us as feeble, even ridiculous, but they nevertheless remained embedded in the finished doctrine, for good or ill. That was not at all the case with the great analogies of nineteenth-century physics, for instance those between the little-understood laws of electromagnetism and the relatively well-known laws of hydraulics. These analogies were promptly discarded as soon as the new theory was alive and kicking. Admittedly they often left behind linguistic evidence of their use, as we are reminded when we speak of electric *currents*, by analogy with currents of water; but the root analogies are to all intents and purposes forgotten, except by historians.

Despite some notable successes, analogy has long had a dubious reputation. For every Tom Sawyer there are a hundred Huckleberry Finns. Even Charles Darwin, who made much scientific use of analogy, called it ‘deceitful’, which indeed it often is, though such a down-beat diagnosis can be almost as dangerous as the disease it is meant to cure. Analogy is potentially very valuable. It allows a familiar explanatory scheme to be applied to a new and relatively unfamiliar domain, if only temporarily. It is deceitful only if we allow ourselves to be deceived, and to forget that it is only a first step into unknown territory, and that it will need to be corrected as we proceed. Its worth will be judged partly by the degree to which correction is needed, and partly by the explanatory power of the fundamental system on which it is based, but in the last analysis it will be judged by the success of the new theory that is developed out of it. With Huckleberry, we must always in the end insist on asking whether bronze horses really can fly.

The example of analogy I shall be considering, that between microcosm and macrocosm, was widely disseminated. It would not be easy to argue that it opened the way to any new scientific doctrine of note. Why was it so popular? Part of my answer will be that we should be looking for other criteria of success than those I have already

mentioned. In introducing this particular analogy I shall show that it meant different things to different people, and that in the last analysis its fame had more to do with poetry and meaning than with logic and science.

THE BEGINNINGS OF THE MICROCOSM-MACROCOSM ANALOGY

As most will agree, the prevailing scientific philosophy of the seventeenth century was a *mechanical* philosophy, in which the world and its parts—even living creatures—were visualised as machines. Many of those who used machine metaphors at that time gave little thought to the implications of their language. They were simply picking up a fashionable figure of speech. There was, however, a long and fruitful tradition of what has been called the ‘rational artist’ that goes back through the middle ages to the ancient world, and in which the metaphor was far from being an idle one. The *De architectura* of Vitruvius was one source of the tradition: the mechanical arts were to be improved by imitating Nature in Vitruvian machines. Vitruvius helped to promote another idea that has survived into the modern world, and that was especially favoured during the Renaissance, the idea that if a building is to be aesthetically pleasing it must have ‘an exact proportion worked out after the fashion of the members of a finely shaped human body’.² Renaissance editions of the Roman writer had diagrams fitting the human body to a geometrical figure—Leonardo da Vinci’s is of course by far the best known instance. Others who enriched the tradition include Dürer, Alberti, and Galileo.

Many Renaissance *virtuosi* had made machines in imitation of nature, not only on the small scale but—in the case of the astronomical clock—on the scale of the universe itself. They were conscious of an act of *imitation* of the work of the divine Creator,³ and so of a double rationality, that of the Creator’s work, and that of their copy. This is one type of analogy that deserves to be put in a category of its own, or perhaps not even described as an analogy at all. It can be seen as an instrument of meaning, but hardly as an instrument of argument or inference. It is a pragmatic analogy, a practical representation of the world. The copy of the world might have served as an instrument of aesthetic or theological practice, but it did not deepen the understanding

² Vitruvius, *De architectura*, III.1.

³ A. C. Crombie, *Styles*, p. 38.

of the mechanism of the world, which was presupposed by the model. This was not always the case with mechanical models of the universe, however.

The mechanical view of the world has a long history, although it has been a history entangled with other ideas of a very different sort. The Myth of Er, in Book X of Plato's *Republic*, speaks of a mechanical model of the world, turning on a spindle on the knees of Necessity. Here is an example in which astronomy and mechanics meet, but with a touch of poetry too. As we shall see later from the biography of Johannes Kepler, the mechanical and spiritual analogues are not mutually exclusive. And let us not forget that, like the Presocratics, Plato explained the concepts of cosmic order and the balance of cosmic forces in terms of social and political imagery, on some occasions using comparisons with living and growing organisms. Aristotle's comparison of living organisms to well-governed cities was no doubt inspired by such Platonic comparisons.⁴ It was Plato above all other Greek writers who provided later history with the idea that the world is not only ordered but the creation of a craftsman-god. Here, surely, are a few of the germs of the idea that the world is a mechanism, something that can be understood in the way a craftsman understands his creations.

The usual literary source named for the all-pervasive doctrine of microcosm and macrocosm in a simple form is Plato's dialogue *Philebus*, where Socrates says that there are four elements in man, just as there are in the Universe. In us they are weak and impure, while in the Universe they are strong and pure—earth, water, air and fire. Socrates asks what holds the elements together in our bodies, and the answer is the soul, from which he was led to suppose that the Universe too has a soul. This is an unashamed use of analogical inference. We find similar ideas in Plato's *Timaeus*, where the cosmos is said to be an image of the Demiurge, so that again there is a parallelism supposed between an intelligent being and the world. Plotinus and later Platonists accepted the notion of a 'soul of the world', *anima mundi*, and began to build on the analogy with the help of Christian and Jewish theology. Aristotle had used the analogy in his *Physics*,⁵ but in the opposite direction, saying that since animals can produce motions in themselves, the same may be true of the world as a whole. Seneca likewise argues from man to the

⁴ 703a 29ff.

⁵ 252b 19-28.

world in his *Natural Questions*,⁶ but here he goes only as far as the earthly world: he says that the body has veins and arteries carrying (as it was thought) blood and air, so the Earth has them, to carry water and air.

The texts containing such ideas are numerous but seldom profound. They are far too numerous for me to survey them comprehensively in a short space, and instead I have chosen a few of the less familiar by-ways of the subject. Astrology is one such by-way. It begged to be introduced into the analogy at an early stage. It was responsible for much of that unsystematic mass of medieval and Renaissance material that related the human body, *inferius animal*, to the sky, *magnum animal*. It was almost always rather unsystematic, but it was spread abroad to a great extent by trained physicians, who considered astrology to be a part of their science and who were occasionally versed in natural magic too. Of course, even as natural magicians they did not claim to be in a position to *control* celestial correspondences, but they did believe that they could work *in sympathy* with the heavens on behalf of their patients.⁷

Quite apart from such practice, various astrological explanations were offered of the parallelism between man and cosmos. Some considered the possibility of an inflowing of material, an 'influence', carrying the cosmos to mankind.⁸ Others had vague models of universal sympathy. There was an astrological doctrine known as *melothesia* which was much more specific, and which related the parts of the heavens (the planets or the signs of the zodiac) to the parts of the human body. This was an idea that was regularly applied in medicine.⁹ It was decreed that no part of the body in whose zodiacal sign the Moon is at any particular moment may be touched then, either with an iron instrument or with medication.

There were many more astrological correspondences worked out on the basis of transparent analogies. Some are very simple, for instance those based on correspondences between the various planets and human tools and occupations that their classical characters seemed to imply—

⁶ Seneca, *Naturales quaestiones*, III.15.

⁷ Controlling celestial correspondences was dimly considered possible with profane practices, namely invocations of spirits, using engraved stones, images, talismans, and so forth.

⁸ See North, 'Celestial Influence', pp. 45-100.

⁹ For a well-illustrated account see Jones, *Medieval Medical Miniatures*.

Mars for the spear and sword, Jupiter for the judge, and so on. The relationship of the heavens to mankind was often described with reference to Holy Scripture. The twelfth-century writer Godefroy de St Victor, for example, composed a work with the title *microcosmus* which picks up Augustine's analogy between ages in the world's history, the ages of Man, and the six days of creation. This sort of hexaëmeral literature based on the Book of Genesis should be added to the stock of medieval and Renaissance literature on microcosm and macrocosm. Among the more famous instances of it are works by Ambrose (*Hexaëmeron*), Robert Grosseteste (*Hexaëmeron*), Pico della Mirandola (*Heptaplus*), Tasso (*Le sette giornate*), and Saluste du Bartas (*La sepmaine*).

How much of all this was seen as an aid to inference or argument in any sense? There is throughout the tacit belief that the deep parallels that are being drawn will help one to understand the unknown in terms of the known, but which is which? The heavens are visible. The heavens declare God's glory. To insist that the microcosm is a reflection of the macrocosm is to insist that man, with whom God finished his work of creation, is a living example of that creation. But this is not a normal reading of scripture. There is nothing in Genesis to the effect that man is made after the image of the *world*. Man is made in God's image. When it is a question of using the microcosm-macrocosm parallel in a religious context I suspect that this was to use an analogy not in an inferential mode but as what might be called an *objective* analogy. They knew the heavens, they knew man, and they knew that God made the analogy between the two. They knew all three. But rather than exploit that knowledge, and make use of the network of parallels for inferential purposes, they simply proclaimed it and took pride in it. They were simply grateful that God had made us as grand in our way as the heavens are in theirs. I think most of us now will find all this philosophically disappointing. But perhaps it makes good theology.

The celestial sciences did not have the field to themselves. The alchemists, who were to some extent motivated by practical—for instance medical—ambitions, and who proceeded in a largely empirical way, had an ardent belief in the parallelism of macrocosm and microcosm, which they inherited from Alexandrian alchemy, to some extent stemming from Plato's *Timaeus*. The supposed links between the two worlds were certain intermediate entities and the so-called *pneuma*, having nothing to do with astrology. In due course, however, alchemy

became intertwined with astrology, regarded as the science of the macrocosm. In this way astrology contributed a certain theoretical component to alchemy—so much so that when one looks casually through a work of alchemy it is often easy to mistake it for a work of astrology. Since theology was also often introduced into the scheme, the truths of nature were for some alchemists the first step to a quest for the nature of the Creator.

MICROCOSM AND MACROCOSM IN TWO CONTRASTING NATURAL PHILOSOPHERS, PARACELSUS AND KEPLER

Such ideas as these were not restricted to the Christian community. They were especially prominent in the new Jewish teaching called Cabbala (Kabbala, tradition), which spread from the Jews of Gerona to the rest of Spain, to Languedoc, and further afield, especially in the first half of the 13th century.¹⁰ The main idea of the Cabbala was to unite the divine element in mankind with the world spirit, and the very language of all this hints at Neoplatonic influences. Pico della Mirandola took Cabbalistic ideas on board, and publicized the microcosm-macrocosm analogy for its hermeneutic value in the understanding of Scripture.

Like so much of medieval mysticism it was all based on a few crude scientific ideas, such as the qualitative doctrine of the spheres of the Aristotelian-Ptolemaic cosmos, on to which was grafted a simple theology. Pseudo-Dionysius and the neo-Platonists had done something similar long before, and just as in their case, so with the Cabbalists, there was a pretence of scientific system and exactitude. The microcosm corresponds to the macrocosm. The doctrine of spheres, of the 'infinite', of emanations and gradations of spirits and angels and material things, was all set down with a laughable pretence at precision, pulled out of thin air. The aim was clear: it was to *connect* every act, every deed, every prayer with the spiritual world.

The Cabbala, with its strange devices for decoding the Hebrew scriptures, is well known. Gematria, one of its techniques, was a method of interpreting the text by interchanging words whose letters have the same numerical value when added together. There we have another way of setting up a connection between two corresponding worlds that were supposedly in a harmonious relationship. Some Christian scholars—

¹⁰ To the school of Gerona belong such masters as Ezra ben Solomon, Azriel of Gerona, Jacob ben Sheshet, and Moses ben Nahman (Nahmanides, or Ramban, c. 1195-1270).

Reuchlin and Pico della Mirandola are the best known—seized on it in the belief that it could produce evidence for their faith, and in particular for the doctrine of the Trinity, although this was plainly not in the thoughts of its Jewish creators. It is based on faith, authority, demons and angels, and the miracles reported in Scripture, but that is not its most interesting characteristic. It has the appearance of analogical argument, but it does not deserve the name, for its only rational pattern involves words considered only as tokens. Their meanings do not enter into the relationship set up between them.¹¹

Not everything in this tradition is quite so vacuous, however. While I have no sympathy with Pico della Mirandola's methods, which are indeed flawed even by his own criteria, it has to be said that he shows some originality and a feeling for the hermeneutic value of the microcosm-macrocosm analogy. He uses it as a way to theological understanding, following in a Neoplatonic tradition stretching from the ancient world to medieval Islam and Christian Europe.¹² Pico noted that the ancients conceived of three worlds, the angelic or supracelestial (intelligible), the celestial (a world of never-ending activity), and our own sublunar world (with its succession of life and death). His entire book on this theme, *Heptaplus* (1491), is a detailed working-out of the triple analogy, on to which he tags humankind, as the fourth estate. He thought that he had hit on a *constructive* argument, leading to new results—in his case to hidden meanings in the book of Genesis, so that he believed he was treading in footsteps of Moses. His hands were tied to some extent, for he had to *reconcile* authorities—Moses, Plato, Aristotle, and many others. Inevitably he introduced many comparisons involving astronomy and natural philosophy, but always with this exegetic purpose.

Paracelsus

As every psychologist knows, merely setting down a list of names or concepts can carry the imagination further afield, but it does so in different ways for different individuals. *Blood, red, cross*, ... what next? For some it might be *ambulance*, for others *holy war*. Parallel lists are

¹¹ In fact it was often a point of pride of Moses ben Shem Tob de Leon, author of its most famous book, the *Zohar* (composed after 1285), that the Bible should *not* be interpreted literally.

¹² He cites, for example, al-Kindi and the twelfth-century writer of *Microcosmos*, Godefroy de St Victor.

even more problematical. There is no such thing as a ‘mere comparison’, as long as the functioning of the terms is left to our imagination. A good analogy sets out as explicitly as possible, for all to see, its functional parallels as well as its lists of concepts. Only then will it have a reasonable rhetorical, logical, or at least pseudo-logical, force. Good early examples are hard to find, but Paracelsus produced somewhat more plausible examples of analogy in the cause of science than most of his predecessors had done, and they have an interesting connection with our theme.¹³ Marsilio Ficino’s translation of the Hermetic corpus in the 1460s had greatly stimulated an interest in natural magic and alchemy. Paracelsus wanted to discover new materials for medicinal purposes, and he hoped to do so by pinpointing the spiritual forces that would make them work. His greatest achievement is usually reckoned to be his abandonment of the old concept of disease as something due to a disturbed balance of the humors. He substituted the idea that diseases have external causes, which it was his task to identify and classify. Being thus led to types of therapy that addressed the external cause rather than the humoral imbalance (such as bloodletting and purging had done), he needed a theory of the cause of disease, and it is here that we see him falling back on analogy.

Disease is a human condition, and mankind was at the focus of his attention, but to someone with his particular background it was a short step from mankind to the macrocosm. He writes as though we contain in ourselves all the minerals, plants and animals of creation. If he had left matters there, his system might have sunk without trace, filled as it is with aphorisms that today look as though they are drawn from a cheap magazine article on alternative medicine. Why they caught the imagination of so many of his contemporaries was, I believe, because they seemed to have a stiffening of rational argument behind them. This was presented in analogical form, mediocre though the actual analogies usually were—they had more to do with cosmic psychology than the cold logic of the universities, but that was no obstacle to their popular appeal. All things were said to have a longing for that out of which they are created,¹⁴ and all beings, with or without sensation, were supposedly

¹³ Theophrastus Philippus Aureolus Bombastus von Hohenheim was born in Einsiedeln, Switzerland, 1493 or 1494, and died in Salzburg, Austria, 1541. ‘Paracelsus’ was a bombastic nickname.

¹⁴ *Werke*, 10, pp. 32-4; *Werke*, 9, p. 293.

penetrated by the astral spirit. Those who know what it is to yearn for something have taken the first step on the road to Paracelsian-style scientific understanding. The body of man longs for food and drink to turn it into flesh and blood. The body returns to the elements at death. The spirit of man longs for spiritual nourishment from the stars, and converts it into works of art and knowledge. The spirit returns to the stars at death.¹⁵ Every object has its star (*Gestirn*) in the sky as well as certain immanent virtues, vital principles—in short, its quintessence, for which the word *Gestirn* is also used. This is all impressionistic and confusing, and the same is true of a range of equivalences—star, mineral, herb, part of the body, disease, cure. It is distinct, however, from the old astrological melothesia, in which each planet or sign of the zodiac is taken to correspond to a specific part of the body.

Surprisingly enough there was a scientific pay-off from this grandiose Paracelsian analogy. *All* bodies on the Earth were said to have characters linked to the stars, their quintessences being comparable with the life-spirit in animals and man, and this made Paracelsus ask how the physician could extract them. It somehow seemed obvious that this might be done by solution and distillation. The methods were traditional, but the outlook of those carrying them out was new. Dissolve and distil, and give due reverence to the result, for whatever else it may be it is a product of the heavens! The point to be observed is that Paracelsus was a sufficiently good physician to judge which of his medicines were working and which were not. Both he and his converts to his method, however, had something in addition to skill: they had *conviction*. The fervour with which their research programme was carried through was not simply a question of rationality. It was comforting for people to think that they had a little bit of heaven in themselves.

Paracelsus's methods yielded useful results, and he was a good enough physician to recognize those which were worth promoting and those that were best forgotten. Even then, his methods did not please everyone. Francis Bacon seems to have feared that in linking man too closely with the universe, and even with its inanimate parts, Paracelsus risked taking

¹⁵ Paracelsus adds further parallels, for instance between iron and the magnet, which yearns for the iron out of which it comes. The thrust of them all is in the same direction, to support the idea of alternative systems with comparable cyclical patterns of birth, desire, death, and return.

away man's humanity.¹⁶ Others feared the spiritual implications of the idea that the natural world may be manipulated by magic. A man who criticised Paracelsus fairly and squarely on his own ground was Van Helmont, who drew attention to *inconsistencies* in his work and its undisciplined character.¹⁷ From that day to this, however, Paracelsus has had a loyal following of like-minded people, even though in time they were relegated to the fringe of academic medicine.

Kepler

Markedly different uses of the microcosm-macrocosm analogy were those developed by Johannes Kepler, a man born in 1571, thirty years after Paracelsus died. Kepler was trained in theology at Tübingen, where as a student he was converted to the heliocentric views of Copernicus. His first position was as a teacher of mathematics at Graz, and there is a well-known story of how, when showing his students at Graz the pattern created by successive conjunctions of Saturn and Jupiter, he was led to a remarkable relationship (as he thought) between the planets' orbits and the proportions of the astrological diagram of the conjunctions.¹⁸ He set out his argument in his *Mysterium cosmographicum* (1596), weaving together his theological ideas on the harmony subsisting between microcosm and macrocosm and celestial kinematics. His methods are often plainly analogical, and he is proud of the fact. His *Mysterium Cosmographicum* is a treatise on the heavens in which he uses arguments somewhat resembling those used by Plato in the *Timaeus* to set up a correspondence between the five regular solids, the five elements, and the astronomical and astrological properties of the planets.¹⁹ He explains how the Platonic solids corresponding to the

¹⁶ For Bacon's and similar criticisms by others (Thomas Erastus, Andreas Libavius, Daniel Sennert, J. B. van Helmont), see Vickers, 'Analogy versus Identity', pp. 135-48.

¹⁷ Vickers, *ibidem*, pp. 144-9. It has to be said that Van Helmont (1579-1644) was a Paracelsian in many respects, in particular in his rejection of the ancient idea that disease arose from an upset of humoral equilibrium.

¹⁸ In brief: the envelope of the lines joining the zodiacal positions at which conjunctions occurred was a circle in the same proportion to the zodiac as was Jupiter's orbit to Saturn's.

¹⁹ In the *Harmonice mundi* Kepler carried his programme many stages further than in the *Mysterium*. He set up the correspondence between the planets and the regular solids as follows. First he found for each regular solid the difference between the radii of the inscribed and superscribed spheres. He then matched these differences to the known intervals between the planetary orbits. Since the match was a rather good one he was able to persuade himself that he had found the key to celestial harmony, that is, by

planetary orbits fall into two classes, and that the Earth comes between them. In this way he explains why man has a central place in the *physical* cosmos—something his religion told him was true on man's *spiritual* plane.²⁰ There is a conscious use of analogical inference here, and not merely of an appealing metaphor. Kepler is not afraid to speak in favour of an analogical method: writing on optics a few years later he called analogies his 'most faithful masters, to whom are known all the secrets of nature'.²¹

It is interesting to see that Kepler places a much higher value on geometrical than arithmetical harmonies. As D. P. Walker pointed out, his analogies here are geometrical and not arithmetical. 'Analogies based purely on numbers correspond to no archetype in the soul of man or mind of God, whereas geometric analogies do so correspond, and, in many cases, are therefore more than analogies: they display the reasons why God created things as they are and not otherwise, or why we are pleased or displeased with certain experiences.'²² Analogies were for him a step towards truths about creation and the human soul. In yet other writings of his touching on physical causes he speaks of motive force as

modelling the nested planetary spheres on a set of nested regular solids. So far so good. If this notorious result had been as exact as Kepler's other laws of planetary motion, we might still be quoting it. In ch. 15 he gave the calculations needed for the correspondence, based on Maestlin's work, which contained errors of calculation, some of which had already been corrected, unbeknown to Kepler. No brief statement can do justice to the fit of Kepler's theory, but crudely put, it is about 90% accurate.

²⁰ The first group comprises cube, tetrahedron and dodecahedron (for Saturn, Jupiter and Mars), with different faces from one another, while at each vertex three faces meet. The second group comprises the octahedron and icosahedron (for Venus and Mercury), which have faces of the same shape (triangles), but with different vertices (where four or five faces meet). See his *Mysterium*, ch. 3 (*Werke*, vol. 1, pp. 29-30). Kepler adds other distinctions, even more forced, one concerning rotational symmetry about a line through the centre, another concerning equilibrium under gravity, and a third numerological (there are two secondaries, an imperfect number, and three primaries, a perfect number).

²¹ Kepler, *Ad Vitellionem paralipomena*, 1604 (*Werke*, 2, p. 92; and see Catherine Chevalley's French translation, p. 224). Kepler's geometrical analogies require a quite different sort of discussion, for they are in an important sense drawn within a single field of discourse, but one that was not widely recognized as such. An example would be identifying analogies between the properties of an ellipse and the properties of a hyperbola.

²² Walker, *Spiritual and Demonic Magic*, p. 237.

anima motrix, a moving spirit, but now he shifts his ground slightly.²³ He tells how, having realised that the motive force falls off with distance from the Sun, he saw that the force must be in a sense corporeal rather than spiritual; and in his *Astronomia nova* of 1609, following William Gilbert's lead, he offers magnetism as the key to planetary force. There is an interesting parallel here with Paracelsus: shaky reasoning, good conclusion. However much we criticise Kepler's law of force, it did help him with his derivation of his second law (the law of areas), the long-term astronomical value of which is undeniable.

Kepler is here standing at the cross-roads between old and new ways of looking at the macrocosm. In a letter to Herwart von Hohenburg (10 February 1605)²⁴ he explains that he plans to show that the celestial machine is not in the nature of a divine living being. It is a kind of clockwork, *instar horologii*, insofar as the multiplicity of motions depends on a single driving force. It is magnetic but corporeal, and so comparable with the driving weight of a clock. The planetary system is *like* a clock, it is the *image* of a clock. The comparison was not new—it occurs in the fourteenth century and earlier—but it is now used in a new way, for it is more than an idle comparison. Kepler is more or less insisting that physical causes be given in mechanical terms, with the added qualification that they are subject to mathematics—arithmetic and geometry. He is tacitly dropping the Aristotelian division of the universe into celestial and sublunar, where different types of law operate. But this does not mean that he has any wish to drop his earlier adherence to mysticism or that he abandons the analogy between microcosm and macrocosm.

His *Harmonice mundi* of 1619 still deals with cosmic harmony, as its title announces, but we ought to bear in mind that it was prompted by a controversy with Robert Fludd, who was a mystic of a very different sort. In 1617 Fludd had published the first part of a massive work which must surely be counted as the most thorough exposition up of that time of the microcosm-macrocosm analogy. Kepler dismissed Fludd as a Hermeticist playing with symbols, occult ideas, and words, and by

²³ This reminds us of the Neoplatonists, and indeed of some elements of Plato and Aristotle, not to mention such moderns as Paracelsus and Bruno, whose work Kepler disdained. But in the second edition of the *Mysterium* (1621) he admits to his source: it was J. C. Scaliger's *De motricibus intelligentiis*. See Kepler, *Werke*, vol. 8, p. 113.

²⁴ *Werke*, vol. 15, p. 146. This general problem is more thoroughly explored in Mittelstrass, 'Methodological elements of Keplerian astronomy', pp. 216-7.

contrast presents himself as a realist. He believes that he has delivered a true and accurate account of the observable world.

Fludd, he says, uses arithmetic in a mistaken manner, whereas his own work, he claims, is truly geometrical. The contrast is especially interesting from our point of view, since at first sight there is little to choose between the style of their analogical presentation. Fludd had given a mystical interpretation of the book of Genesis as an instance of divine alchemy. He considered the Holy Spirit to be located in the Sun, from whence it poured out its influence. Among the numerous subsidiary analogies he worked into his microcosm-macrocosm theme was a three-cornered one between the circulation of the blood, the circulation in the solar system, and the circulation of a spirit coming to man from the atmosphere (aerial saltpetre). What he wrote on musical harmony in the macrocosm, however, was what most irritated Kepler.²⁵ Fludd, he says, writes as though he was treating the three-dimensional (Platonic) solids as though they conveyed Pythagorean meanings. For Kepler they were reality, the thing itself.²⁶

True to observation though Kepler's astronomical account might have been judged, still we find his earlier programme occupying his thoughts. In the last chapter of his *Harmonice Mundi* he spells out yet another analogy between the solar system and the workings of the mind.²⁷ Prefixing it with the remark that it is permissible to use 'the thread of analogy' to make one's way through the 'labyrinth of Nature's mysteries',²⁸ he reaches a strangely antiquated conclusion. If the Earth were not in its mid-position, he tells us, human thought would never have been able to work out the astronomical properties of the planets. (This is almost an anticipation of the so-called Anthropic Principle.) He adds that if there were an intellect on the Sun it would know the

²⁵ The controversy has attracted much attention—E. Cassirer, W. Pauli, R. Lenoble, E. Garin, and F. Yates helped to turn this into a theme with a life of its own—but chiefly from the point of view of the Hermetic movement. For references see Yates, *Giordano Bruno*, p. 442, n. 1.

²⁶ Non sunt illae comparatae, ut Pythagorae *intentiones*, sed ut rem ipsam, quinque scilicet corpora ad astronomicam veritatem accommodent (*Werke*, vol. 6, p. 428).

²⁷ It is an analogy between (a) the rotation of the central Sun that carries the planets round by forms that it emits / the individual planets in revolution about it, and (b) the stirring action of the mind's simple intellection / the discourses of reason stimulated by the unfolding of the mind's simplicity.

²⁸ *Werke*, vol. 6, p. 366.

harmonies *a priori* without any effort of reasoning. Here is a man in thrall to analogy, and still determined to breathe life into that between macrocosm and microcosm.²⁹

EMBLEMS AND SIGNATURES. THE DEATH OF ARMCHAIR SCIENCE

Despite Kepler's enthusiasm and his long string of successes, the popularity of the analogy was waning. There is no such thing as a date of death for so pervasive an idea, or for the cluster of ideas that hung like a cloud around it, but certainly they have all but disappeared from the writings of those whom we most value for their scientific work after the seventeenth century. There was still some life left in the macrocosm-microcosm analogy, but as an instrument for the understanding of other things than the physical world. It was used wherever theologians spoke of divine hierarchies, and also in political treatises, following in the tradition established by Plato. John of Salisbury had compared the body and the state at some length: the prince was the head of the body politic, the army was his arms, and so on. Thomas Hobbes and many other writers of the seventeenth century followed suit, often adding references to the harmony of the heavens, the hierarchical arrangement of which was supposed to correspond to that of kingdoms or empires. This appeal to an analogy of hierarchy could in principle have been used to instruct people in the art of designing states and constitutions, but more often than not it was something else. It was usually a question of *justifying* either the status quo or a desired system, by spelling out the consequences of the analogy and making them seem desirable, or at least not unacceptable.

In Judaeo-Christian theology the analogy survived longer. Theologians, especially Jesuit theologians, had a way of representing the world through the use of emblems, whether they were converting the simple-minded or talking high science.³⁰ They saw nature as a collection

²⁹ There are others that we now judge more important but that chiefly concern geometrical astronomy. On one occasion he shows us that he was so convinced of the correctness of his analogy between planetary spheres and nested polyhedra that he was led to reject certain of Copernicus' geometrical constructions. There was a clash of epicycles (Maestlin first drew his attention to the fact) so Kepler reverted to the equant that Copernicus had rejected. This was very fortunate: it turned out to be a short step on the long road to Kepler's law of areas.

³⁰ The point about the Jesuits is well made by Ashworth, 'Catholicism and Early Modern Science', pp. 156-7.

of signs and metaphors. We are reminded of the many scholars who accepted the doctrine of signatures, and who remained deaf to Francis Bacon's criticism of them.³¹ Step by step the idea that everything in nature carries a hidden meaning—whether the universe or man, whether an atom or a star—was becoming recognized for what it was, a way of getting results with a minimum of effort. Nature's reputation was changing. She was casting off her human attributes and becoming an object of empirical study, requiring hard mathematical analysis. Emblems and simple images were more easily comprehended than sermons, and they were decorative into the bargain, but they were just too easy. Those who insisted on accepting them as a substitute for the best science of the age were fortunately fighting a lost cause.

Appendices

I. KEPLER AND MUSICAL HARMONIES

Employed by Tycho around the turn of the century, and set to work on the problems surrounding the motion of Mars, Kepler had studied highly specific numerical harmonies among the planets—harmonies between their maximum and minimum velocities, and harmonies between the orbital elements. By 1618 he was in possession of what we now call his third law of planetary motion, *before* he could provide it with a firm empirical basis. Unlike many his earlier harmonies, this turned out to be extremely exact. He went on trying for exactness elsewhere, notably in musical harmony. Polyphony was a relatively modern invention—one whose importance musicians tell us was comparable with the discoveries of Copernicus. Kepler, in the *Harmonice Mundi*, adds to it an invention of his own, namely that each planet plays scales, like simple song or monody, 'the only kind known to the ancients', and that the planets as a

³¹ See Appendix III.

whole play chords.³² Again he insists on the importance of observation, celestial and musical.³³

II. KEPLER ON SYMBOLIC REPRESENTATION

I have represented Kepler's view of analogy as a rather stern, causal, view, even in his flights of fancy at the end of the *Harmonice Mundi*. He occasionally played with symbolic representations, and even admitted that he was doing so—for instance when describing with some sexual detail how a major third is masculine and active, while a minor third is feminine and passive, 'like a hen ready to be mounted by a cock'.³⁴ But he believed that

nothing is proved by symbols, nothing hidden is discovered in natural philosophy through geometric symbols; things already known are merely fitted [to them]; unless by sure reasons it can be demonstrated that they are not merely symbolic but are descriptions of the ways in which the two things [i.e. the two terms of the analogy] are connected and of the causes of this connexion.³⁵

He is speaking here against the seductive charm of symbolisms and staking his own claim to be dealing in real causes. It was a cliché of the age that the heavens were merely signs, and not causes, although many occultist thinkers took a very different view.³⁶ Kepler insists that he is not 'merely symbolizing', in the way people were who associated Saturn with snow, Mars with thunder, and so forth. He believed that he had

³² The modern music that he needs here resembles celestial music, but does not derive from it. To quote Walker, *Spiritual and Demonic Magic*, pp. 233-4: 'both are likenesses of the same archetypes, the geometric beauties coeternal with the Creator...'.
³³ Had the ancients given more attention to observation, he thought, his discovery of the polyphony of the heavens would have been made earlier; the Pythagoreans and Platonists were simply not subtle enough in their analyses. This is of course to take an anachronistic view of Plato's use of the forms, and of scientific style and ambitions in Plato's time.

³⁴ Walker, *Spiritual and Demonic Magic*, p. 244, n. 76.
³⁵ *Ibidem*, p. 245, translated from *Werke*, vol. 16, p. 158. Kepler was responding to a present of a work by Andreas Reinhard, *Monochordum*, which contained sexual analogies.

³⁶ The idea of a real connection (occult but active powers and forces) between the sign and the thing signified was exploited not only by those who practised magic in an obvious sense, but by many who advocated the mnemonic techniques that linked places (for instance in the clearly remembered framework of a theatre) and images of other things. Kepler was perhaps not as free from such beliefs as he thought.

found potential *causal* analogies between music, the refractive indices of materials, sexual desire, planetary orbits and motions, and so forth, and that observation may prove some or all of them in the end to be real.³⁷ What is more, he also believed that he knew *why* his analogies, insofar as they were true, were real. It was because God had modelled the two sides of the analogy *on the same geometric archetype*.

At first sight one might say that this is not modelling in the usual modern sense of that word—as when, say, William Thomson built a system of linked springs and hemispheres to represent the structure of matter—but indeed it is very much the same. Kepler seems to me to have put his finger on an extremely important point. He has appreciated that *analogies function because they share a mathematical (or other formal) structure*. Logicians who discussed analogy down the ages tended to miss this point, simply because the simple analogies they used as examples shared what was usually a very trivial formal structure.

III. BACON ON SIGNATURES

After giving several examples of analogy in his *Novum Organum*, mostly biological (such as the resemblance of the eye to a lens), Bacon stresses the point that resemblances should be studied, ‘For these it is that detect the unity of nature, and lay a foundation for the constitution of science’.³⁸ He adds a word of caution: we are only to take seriously ‘real and substantial resemblances’, ‘resemblances grounded in nature’, and not those that are ‘accidental or merely apparent’. Much less are we to accept

superstitious or curious resemblances, such as the writers on natural magic (very frivolous persons, hardly to be named in connexion with such serious matters as we are now about) are everywhere parading; similitudes and sympathies of things that have no reality, which they describe and sometimes invent with great vanity and folly.

In a passage written in the same critical spirit in his *Historia vitae et mortis*, Bacon rejects the doctrine of signatures—he gives as an example

³⁷ Indeed, one of Kepler’s problems was that he was so in love with his harmonies that when he found his laws of planetary motion and did not retract the old correspondences his total system became overdetermined and inconsistent. There is then the question of which archetypes were supposed to have priority.

³⁸ Bacon, *Novum Organum*, ed. Ellis and Spedding, p. 167.

(among others) the belief that eating the flesh of deer will renew life.³⁹ The acceptable instances he gives are acceptable only by virtue of their familiarity to his readers, whether in everyday life or in some such familiar book as the Bible. He makes use of the familiar and persuasive analogy between light and knowledge, for instance, but ultimately—and not surprisingly—he gives no criterion for resemblances ‘real and substantial ... grounded in nature’. The subtleties of scholastic semantics were not for him, and that was perhaps because he was conscious of so very much contemporary scientific writing, good and bad, in which scholastic niceties had been successfully swept aside by analogy-makers.

It should be noticed that Bacon’s example of an association of the deer with Saturn may be analysed in different ways. It could be seen as a merely nominal correspondence of two words on parallel lists. The doctrine of signatures, on the other hand, could mean much more, in this case the stamping of Saturn’s character on the deer in some quasi-causal way. There might in principle have been an even stronger causal connection, with say an influx of something coming from Saturn. Just as in this simple example, so in analogical argument generally, there is a wide range of possible attitudes to the causal or ‘real’ basis of analogies. At one extreme there will be the idea that there is a parallelism of names and syntax, and nothing more. At the other extreme there is the belief that analogies only work because they have a basis in reality. In the first case people may apologize for their analogies, but in the second they do not.

³⁹ This was advocated by Jacques Lefèvre d’Étaples, although Bacon is not necessarily quoting him. Lisa Jardine, following Spedding, believes that the examples Bacon selected were taken in fact from a work by his namesake Roger Bacon.

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